Jameco Part number 143802

This is a Motor Mind B test routine. The lines prior to START ensure that the Motor Mind B is not in SPDCON mode and reduce the motor speed to zero before continuing. The routine sends the Motor Mind B a duty cycle of $FF which will turn a motor fully on. It then reverses the motor, waits a second and stops the motor. After a half second delay the motor will then be turned on at full speed (it will still be reversed). The routine then waits 2 seconds and sends a TACH command with a confirmation request. If no tach is connected a H'0000' will be returned. The next command is SPDCON, or speed control. In this mode the Motor Mind be will increase or decrease the duty cycle of the motor until the tachometer equals the desired frequency (in this case H'03E8' or 1000Hz). If no tachometer motor speed and then quit.

```
            LOW         14
            PAUSE       1250
            HIGH        14
            PAUSE       3000
                            send H'00' duty cycle to motor mind B
            SEROUT      14,396, [$55,$03,$00]
            PAUSE       3000
b4          =           $FF
START:
                            send H'FF' duty cycle to motor mind B
            SEROUT      14,396, [$55,$03,b4]
            PAUSE       1000
                            send REV command
            SEROUT      14,396, [$55,$01]
            PAUSE       1000
                            send STOP command
            SEROUT      14,396, [$55,$00]
            PAUSE       500
                            send H'FF' duty cycle to motor mind B
            SEROUT      14,396,[$55,$03,b4]
            PAUSE       2000

EMERG:
                            send TACH command with confirmation request
            SEROUT      14,396,[$55,$82]
            SERIN       15,396,1500, EMERG, [b3,b5,b6]
            IF b3       <> $AA THEN EMERG
            DEBUG       ISHEX2 b4, TAB
            DEBUG       ISHEX2 b5, TAB
            DEBUG       ISHEX2 b6, CR, CR
            b4          = b4 + 1
            IF b4       = 0 THEN SPEED_CON
            GOTO        EMERG
SPEED_CON
                            send SPDCON command for 1000Hz tach level
            SEROUT      14,396, [$55,$04,$03,$E8]
END:
```

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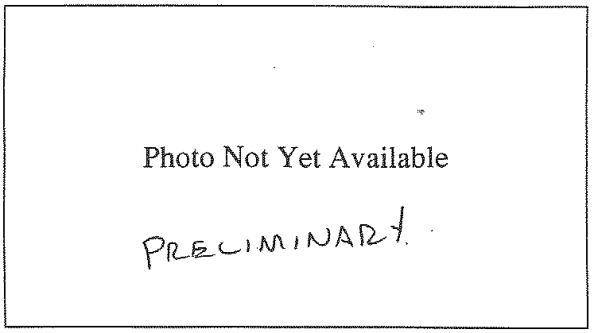
MINI-MODS

● ● ● ● ● ● ● ● Miniature Engineering Modules

Motor Mind B



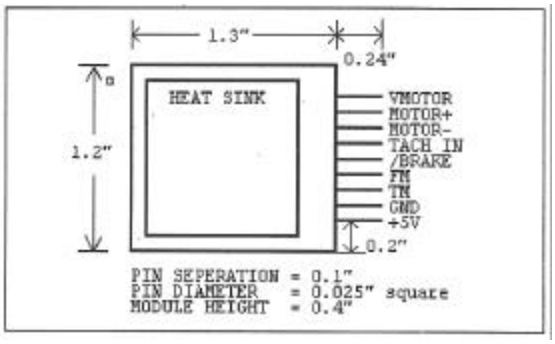
Description

The Motor Mind B is the enhanced version of the Motor Mind Mini-Mod. Motor control is simplified to a serial communication stream. The short instruction set allows the user to implement complex control algorithms quickly and with little effort.

Bi-directional DC motors with operating voltages as great as 30Vdc can be used with the Motor Mind B. This module can handle peak currents as large as 3.5A and continuous currents of 2A. Package power dissipation must not be exceeded during use.

Features include the ability to read a motor's tachometer frequency, automated speed control, 254 discrete steps of speed control, and motor direction changes. The Motor Mind B comes complete with a watchdog timer to eliminate the possibility of a system firmware failure.

The Motor Mind B's small size and new connection scheme allows the device to be inserted



directly into circuit boards for production runs.

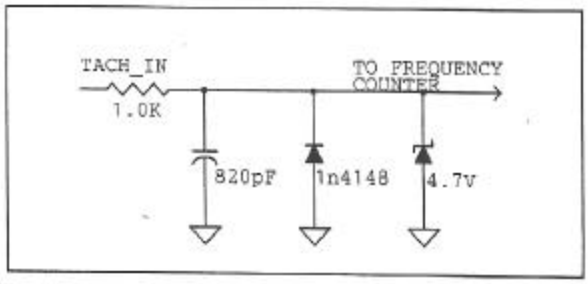
Mechanical Specifications

● ●

Pin Descriptions

VMOTOR	Positive voltage supply for motor(<30V).
MOTOR+	DC motor lead connection.
MOTOR-	DC motor lead connection.
TACH_IN	Input for encoders and tachometers.
/BRAKE	Stops motor when low, does not reset module, communication can continue.
FM	Data received From Master on this pin.
TM	Data sent To Master on this pin.
GND	Ground potential, grounds are common.
+5V	Supply input for control circuits.

Tachometer Input



The TACH_IN circuit is provided for reference. Make sure that your motor's tachometer or encoder is not adversely effected by the circuit above. The tachometer signal level should be between 5-30V. The tachometer circuit reads in values from 0-65,535Hz in 8Hz increments. Measurement errors are in the area of +/-2%. Input signals such as sine waves and square waves with uneven symmetry will work.

Operational Ratings

Operating Temperature:	-20°C to 85°C
Storage Temperature:	-55°C to 150°C
Voltage on TM,FM,/BRAKE:	-0.3V to 7.0V
Maximum Current Sunk by TM/FM pin:	-25mA
Maximum Current Sourced by TM pin:	5mA
Maximum 5V Supply Current:	25mA
Motor Voltage Range:	5-30VDC
Peak Motor Current:	3.5A
Maximum Continuous Current:	2.0A
Max. Current, no cooling fan:	1.3A
Tach Frequency Range:	0-65,535Hz
SYNC Byte:	hex55 b"0101 0101"
STOP Command	hex00, b"x000 0000"
REV Command:	hex01, b"x000 0001"
TACH Command:	hex02, b"x000 0010"
SETDC Command:	hex03, b"x000 0011"
SPDCON Command	hex04, b"x000 0100"
Confirmation Byte:	hexAA, b"1010 1010"

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Additional Features

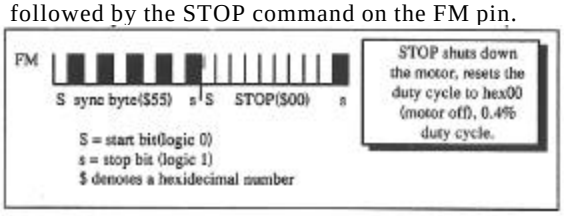
Confirmation Byte - By setting the highest bit of a command byte you can have the Motor Mind B send a confirmation byte on the TM pin whenever it receives a command. The confirmation byte is hexAA, and is sent 0.5ms after a valid command is received. This can be used in noisy systems as feedback for the Master unit to ensure motor control is being achieved.

BRAKE Pin - A logic low at the /BRAKE pin shuts off the H-bridge driver. This can be used as an emergency shut off switch. It does not stop the Motor Mind B from receiving or implementing communication. Logic devices pulling the pin low will have to sink 5ma of current.

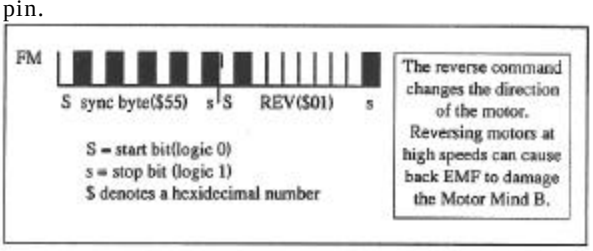
Commands & Communication Protocols

The following timing diagrams detail the methods for sending commands to the Motor Mind B. Communication is at 2400 baud, 8N1(1 start bit, 8 data bits, 1 stop bit, no parity). The Motor Mind B expects to see the least significant bit(LSB) first, and it sends the LSB first. All communication to the module occurs on the FM(From Master)pin. Commands are prefaced with a sync byte which is always hex55. If the high bit of the command byte is set then a confirmation byte will be returned. See AN-301 for use of the confirmation byte.

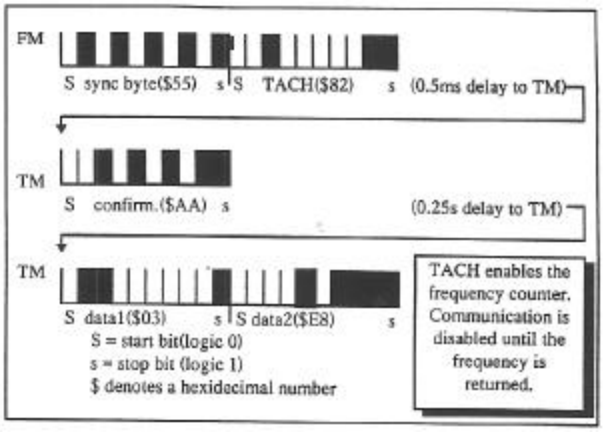
STOP command - Master unit sends the sync byte followed by the STOP command on the FM pin.


FM
S sync byte($55) s S STOP($00) s
S = start bit(logic 0)
s = stop bit (logic 1)
$ denotes a hexidecimal number
STOP shuts down the motor, resets the duty cycle to hex00 (motor off), 0.4% duty cycle.

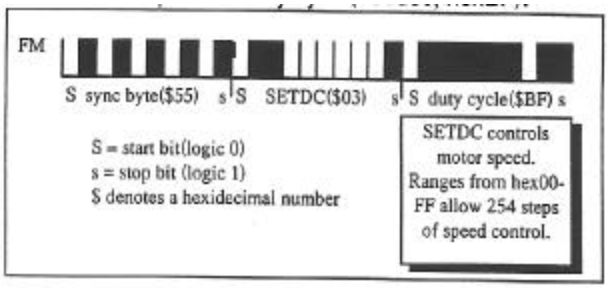
REV command - Master unit sends the sync byte followed by the REV, or reverse, command on the FM pin.


FM
S sync byte($55) s S REV($01) s
S = start bit(logic 0)
s = stop bit (logic 1)
$ denotes a hexidecimal number
The reverse command changes the direction of the motor. Reversing motors at high speeds can cause back EMF to damage the Motor Mind B.

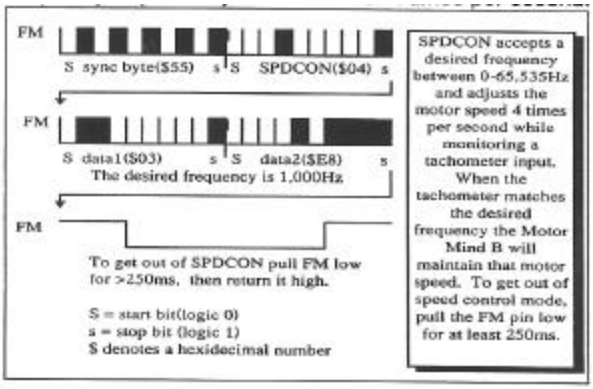
TACH command - Master sends the sync byte followed by the TACH command on the FM pin. In this example the confirmation byte is implemented. Note that the highest bit of the command is set. If the command is acknowledged, the Motor Mind waits 0.5mS then returns a confirmation byte on the TM pin. After another 1/4S the Motor Mind sends the frequency of the signal at the TACH_IN pin to the Master unit on the TM pin. This value is sent as two bytes. The high byte is sent first. Below is an example of a 1kHz signal being read.


FM
S sync byte($55) s S TACH($82) s (0.5ms delay to TM)
TM
S confirm.($AA) s
(0.25s delay to TM)
TM
S data1($03) s S data2($E8) s
S = start bit(logic 0)
s = stop bit (logic 1)
$ denotes a hexidecimal number
TACH enables the frequency counter. Communication is disabled until the frequency is returned.

SETDC command - Master unit sends the sync byte followed by the SETDC command on the FM pin. The command is then followed by the positive duty cycle value. The range is hex00-hexFF(0-255dec.). The minimum duty cycle is 0.4%, the maximum is 99.6%. While the Motor Mind B accepts 256 discrete steps Hex00 is implemented as a hex01 and hexFF as a 254. The higher the number the faster the motor will turn. Below is an example of a motor being turned on with a 74.5% positive duty cycle(191dec, hexBF).


FM
S sync byte($55) s S SETDC($03) s S duty cycle($BF) s
S = start bit(logic 0)
s = stop bit (logic 1)
$ denotes a hexidecimal number
SETDC controls motor speed. Ranges from hex00-FF allow 254 steps of speed control.

SPDCON - Send the Motor Mind B the speed control command, hex04, followed by the high byte then low byte of the frequency desired. The Motor Mind B will read in the tachometer signal and adjust the duty cycle of the motor until the tachometer matches the desired frequency. Speed adjustments occur 4 times per second.


FM
S sync byte($55) s S SPDCON($04) s
FM
S data1($03) s S data2($E8) s
The desired frequency is 1,000Hz
FM
To get out of SPDCON pull FM low for >250ms, then return it high.
S = start bit(logic 0)
s = stop bit (logic 1)
$ denotes a hexidecimal number
SPDCON accepts a desired frequency between 0-65,535Hz and adjusts the motor speed 4 times per second while monitoring a tachometer input. When the tachometer matches the desired frequency the Motor Mind B will maintain that motor speed. To get out of speed control mode, pull the FM pin low for at least 250ms.

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Mini-Mods

AN_301

Using the Motor Mind B SETDC, TACH, REV, STOP, SPDCON commands, and confirmation byte, with a Parallax Basic Stamp^2

This application note cycles through all of the commands available to the user in the Motor Mind B. Each command makes use of the confirmation byte. To disable the confirmation byte function, simply change the highest bit in the command byte to zero. For instance, to send a REV command with a confirmation byte returned to the Stamp you would send the value Hex'81' (binary '1000 0001'). To send a REV command and tell the Motor Mind B not to return a confirmation byte you would send the command Hex'01' (binary '0000 0001').

The first leg of this routine sends a STOP command with a request for a confirmation byte, H'80'. The routine will display the confirmation byte to the "debug" display. After the STOP command is received the Motor Mind will reduce the duty cycle to 0.39%, and pause for 3 seconds.

When the pause is complete, the routine sends the SETDC command with a request for a confirmation byte, H'83', with a new duty cycle of H'DD'. The routine will display the confirmation byte to the "debug" display. After the SETDC command is received the Motor Mind will increase the duty cycle to 86.3%, and pause for 3 seconds.

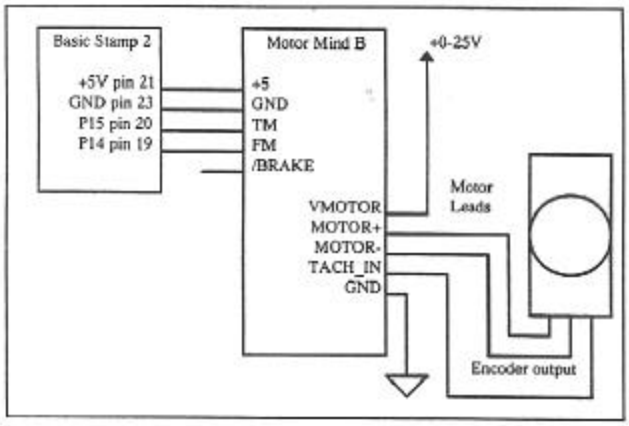
The third command sent is the REV command with a confirmation request, H'81'. The routine will display the confirmation byte to the "debug" display. When this command is received the motor direction will be reversed. At high speeds/voltages motor reversal can cause significant back EMF. Back EMF voltage spikes can damage electronic components if they are large enough.

Command four is the new and improved(compared to the first Motor Mind) TACH command. The tachometer input circuit is now accurate up to 65Khz. Once the confirmation byte is received the frequency is being measured by the Motor Mind B. After a quarter second the frequency will be returned to the debug screen. The high byte is returned first, followed immediately by the low byte. This value, while in hex format, has already been converted to frequency for you. Take note of the extended period that SERIN will wait for returned data after a TACH command is sent. After the tachometer frequency is received this routine pauses for 3 seconds. This give you ample time to wonder at the neatness of it all.

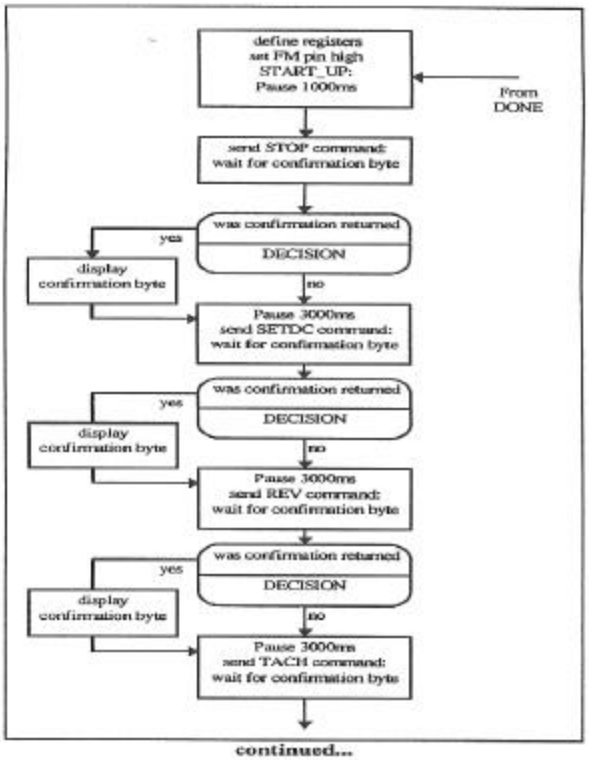
Command number five is the pride and joy of this new Motor Mind B. This is the SPDCON command, H'84'(H'04' without a confirmation request). When sent this command is accompanied by two bytes of data. The first is the high frequency byte, followed by the low frequency byte. A confirmation byte is returned after all three bytes have been received by the Motor Mind B. Once in speed control mode the Motor Mind B will continuously read the tachometer and adjust the duty cycle so that the tachometer frequency meets that of the SPDCON frequency. Adjustments in duty cycle are made in 0.39% increments/decrements and occur roughly four times per second. The duty cycle will not be reduced below 0.39% or increased beyond 99.61% regardless of the tachometer input.

In this routine the frequency sent by the SPDCON command is 2,500Hz, the routine will maintain this mode for 60 seconds. To get out of the speed control mode the FM line must be pulled low for the duration of a tachometer read (at least 250ms). After which if you return the FM line high for 25ms or so, the Motor Mind B will be running in it's normal program mode. In other words, if you use the speed control mode, the Motor Mind B will not acknowledge any more commands from the master unit until it is released from the speed control mode using the method detailed above.

Hook-up Diagram



Software Flow Chart



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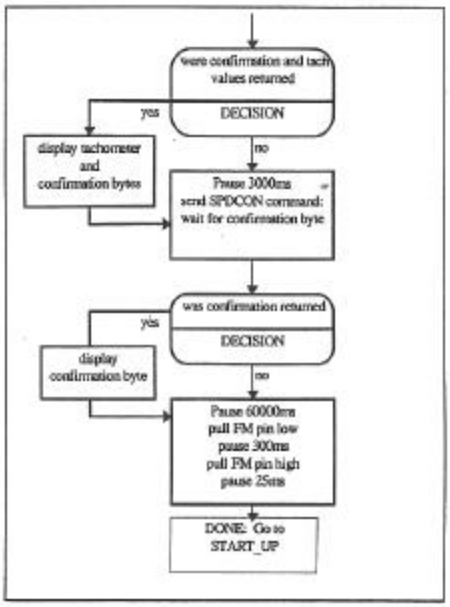

Software Listing: AN_301.BS2

This routine runs through the entire command set available to users of the Motor Mind B. The routine will loop through itself roughly every 75 seconds. The confirmation byte and DEBUG routine are used to signal the user that a new command has been sent to and received by the Motor Mind B.

```
OUTPUT 14
INPUT 15

TM      CON     15
FM      CON     14
HIGH    FM

START_UP:
        PAUSE 1000

Send STOP command

        SEROUT FM,396,[$55,$80]
        SERIN TM,396,100,NO_CONF1,[b7]
        IF b7=$AA THEN CONFIRM1
        GOTO NO_CONFIRM1

CONFIRM1:
        DEBUG ISHEX2 b7,CR
NO_CONFIRM1:
        PAUSE 3000

Send SETDC command, set duty cycle to H'DD', or
86.2%, (Dec 221 out of 256 possible)

        SEROUT FM,396,[$55,$83,$DD]
        SERIN TM,396,100,NO_CONFIRM2,[b7]
        IF b7=$AA THEN CONFIRM2
        GOTO NO_CONFIRM2
CONFIRM2:
        DEBUG ISHEX2 b7,CR
NO_CONFIRM2:
        PAUSE 3000

Send REVERSE command to reverse motor direction

        SEROUT FM,396,[$55,$81]
        SERIN TM,396,100,NO_CONFIRM3,[b7]
        IF b7=$AA THEN CONFIRM3
        GOTO NO_CONFIRM3
CONFIRM3:
        DEBUG ISHEX2 b7,CR
NO_CONFIRM3:
        PAUSE 3000

Send TACH command and read back/display
tachometer frequency

        SEROUT FM,396,[$55,$82]
        SERIN TM,396,1000,NO_CONFIRM4,[b7,b8,b9]
        IF b7 = $AA THEN CONFIRM4
        GOTO NO_CONFIRM4
CONFIRM4:
        DEBUG ISHEX2 b7," "
        DEBUG ISHEX2 b8      ;Display tach. high byte
        DEBUG ISHEX2 b9,CR ;Display tach. low byte

NO_CONFIRM4:
        PAUSE 3000

Send SPEED CONTROL command, freq, set to
2500Hz(H'09C4'), maintain control for 60s

        SEROUT FM,396,[$55,$84,$09,$C4]
        SERIN TM,396,100,NO_CONFIRM5,[b7]
        IF b7 = $AA THEN CONFIRM5
        GOTO NO_CONFIRM5
CONFIRM5:
        DEBUG ISHEX2 b7,CR
NO_CONFIRM5:
        PAUSE 60000

Return to normal operating mode
        LOW     FM
        PAUSE   300
        HIGH    FM
        PAUSE   25
DONE:
        GOTO START_UP
END:
```

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Mini-Mods

AN_302

Power dissipation considerations for the Motor Mind B SMT package.

This application note explains some power dissipation considerations for the Motor Mind B. The power dissipation of the H-bridge driver can be approximated by using the circuit values supplied by the Allegro MicroSystems Inc. data sheet for the A3952SLB motor driver chip. We would also like to thank our valued customer Ralph W. for his insight and input into power dissipation calculations for the original Motor Mind. The power dissipation capability of the A3952SLB without a heat sink, can be described by,

Pic = Tj - Ta/Ric

Where
Pic = Power dissipation of the IC: A3952SLB
Tj = Maximum junction temperature of the IC
Ta = Maximum ambient temperature
Ric = Thermal resistance of IC: A3952SLB

Assuming the maximum junction temperature of the A3952SLB is 150C, and the maximum ambient temperature is 75C, then we solve the equation for,

Pic = 150C - 75C / 67(C/W)
Pic = 1.11W

The total power dissipated by the chip is based on the motor current, which also effects the saturation voltages of the bipolar transistors that make up the H-bridge driver. Since power dissipation occurs in two transistors in an H-bridge driver, the power dissipation can be calculated from the equation,

Ptot = #transistors*Vce(sat)*Iload / 0.85

The 0.85 is the Ralph factor. Our customer Ralph W. came up with a good approximation of Ptot based on the fact that the power dissipated by the H-bridge is the largest factor in power dissipation for this chip. Other factors such as logic circuit power dissipation can be approximated by dividing the H-bridge power dissipation by 0.85. In other words 85% of the power dissipated is done so by the H-bridge driver. The following values are from the Allegro data sheet,

For Iload of 2A Vce(sat) = 1.8V max
For Iload of 1A Vce(sat) = 1.4V max
For Iload of 0.5A Vce(sat) = 1.2V max

For Iload of 2A Ptot = 8.47W max
For Iload of 1A Ptot = 3.29W max
For Iload of 0.5A Ptot = 1.41W max

Remember that the motor voltage does not have any significant effect on these calculations. A 10V motor drawing 2A requires about the same power dissipation as a 30V motor drawing 2A. Using the H-bridge characteristics for a 0.5A load, you can calculate the maximum load current without a heat sink.

Pic = 2*Vce(sat)*Iload / 0.85
1.11W = 2*Vce(sat)*Iload / 0.85
Iload = 0.85*1.11W / 2*1.2V
Iload = 390mA

So 390mA is the largest current that you could expect the Motor Mind B to supply to a motor without a heat sink. Can the Motor Mind B supply a constant 2A of current to a motor? You betcha! All you need is a little thermal management. We selected a heat sink for the Motor Mind B that met several criteria. In short, we wanted the heat sink to provide power dissipation, but not create mounting problems because of physical size. Also, due to the small surface area of the H-bridge driver we began to see that larger heat sinks did not provide significantly larger power dissipation for the product. For these reasons we selected the Wakefield 658-25AB heat sink, and used Wakefield's Delta Bond 156-K to adhere the heat sink to the H-bridge driver.

To determine the maximum current handling capability of the Motor Mind B with no cooling fan(heat sink only) you can use the natural convection chart provided by the manufacturer for the heat sink. At a temperature differential of 75 degrees C the heat sink can dissipate about 4.3 Watts. Using the power equation, and Vce(sat) for a 1.0A load we can calculate the maximum load current with no cooling fan.

4.3W = 2*1.4V*Iload / 0.85
3.66W = 2.8V*Iload
Iload = 1.31A

This value proved correct in testing. At a continued load current of greater than 1.3A the Motor Mind B went into thermal shutdown.

A cooling fan was used to run the device with a constant load current of 2A. We connected a 24V - 37CFM fan between the VMOTOR and GND pins of the Motor Mind B. With the fan 8" away from the device we ran a 2.0A resistive load for 48 hours with no thermal shutdown occurring.

Although it is possible, we never damaged the device when running it at power levels greater than those detailed here. At greater power levels the device went into thermal shutdown. This causes the power dissipation to diminish. When the device cools down it turns back on. Thermal shutdown can exhibit itself as the motor shutting down and then turning on at about 1 second intervals. As the device heats up the motor will eventually fail to come back on line. If you see this condition developing remove power from the Motor Mind B's VMOTOR pin, and find a way to cool down your system. Just don't pour water on it!